Project: IEEE P802.15 Working Group for Wireless Personal Area Network (WPAN)

Submission Title: [Ray-Tracing Simulation of the NICT Channel Measurements]
Date Submitted: [18 July 2006]
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Re: [Response to the TG3c channel model subgroup call for channel models]
Abstract: [Ray-Tracing simulation of the NICT data for the 60 GHz Channel Model]

Purpose: [Contribution to 802.15 TG3c at the July 2006 meeting in San Diego, USA]

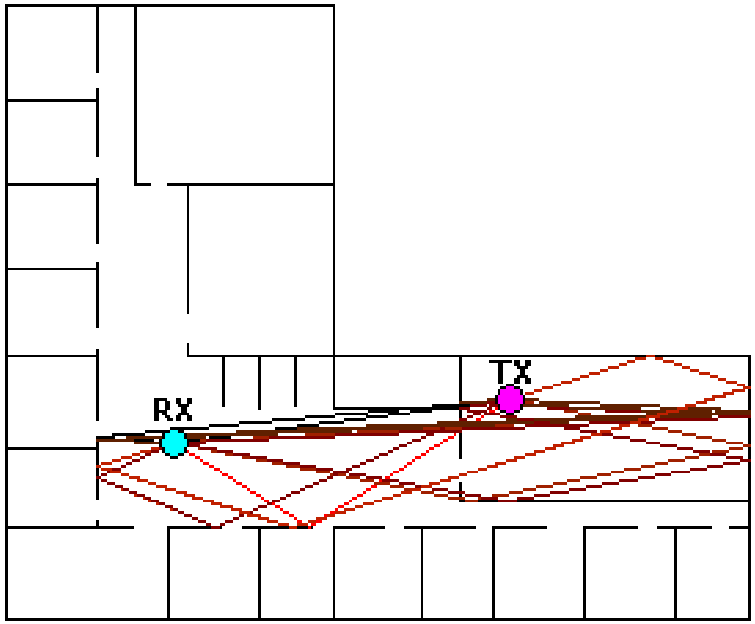
Objective

- To compare the results of the deterministic ray-tracing simulation with empirical measurement obtained by NICT (LOS & NLOS)
- To investigate the effectiveness of ray-tracing in creating channel realization for 60 GHz indoor environments

Wireless System Engineering (WiSE)

• Wireless System Engineering (WiSE) is a ray-tracing tool that has been developed and verified by Bell Laboratories. It provides the complex impulse response of the channel.

• We have used WiSE package to simulate the same indoor propagation environment that was experimentally done by NICT.

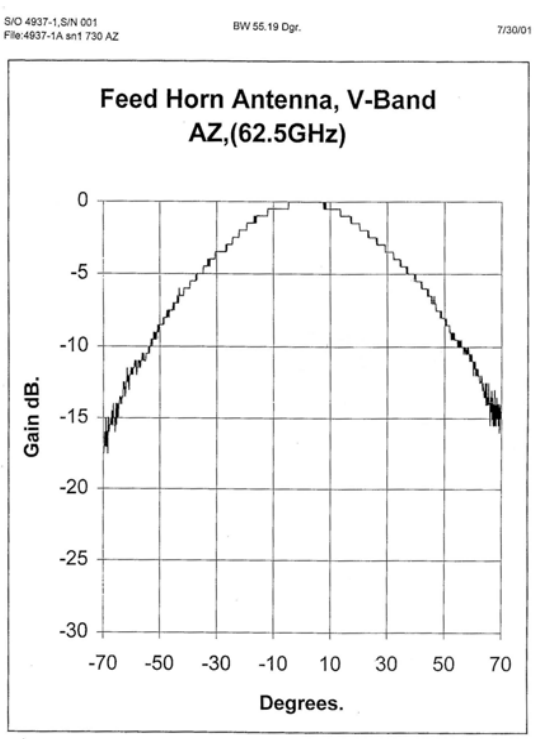


WiSE Sample Output

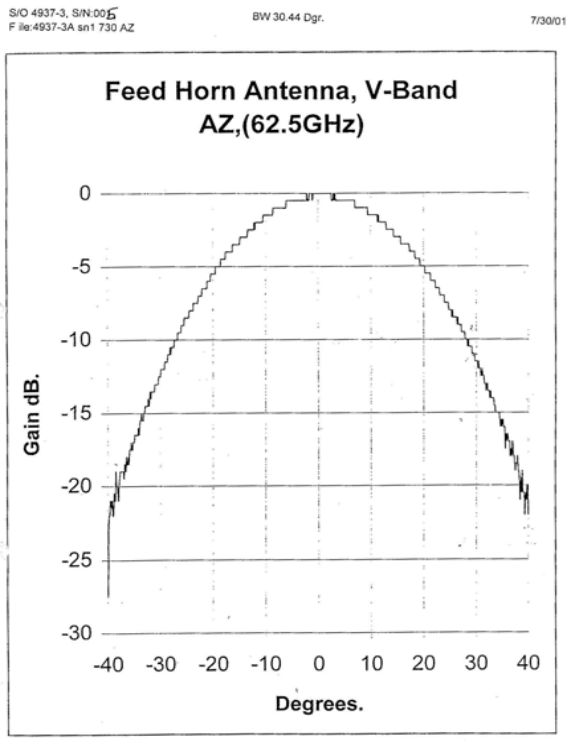
NICT Measurement (Residential, LOS)

- Room with “NO FURNITURE”
- LOS path between the TX and RX
- 3 large windows (plane glass) on two intersecting walls
- Wooden door, floor and ceiling
- Surface of a wall and ceiling are covered with wallpaper

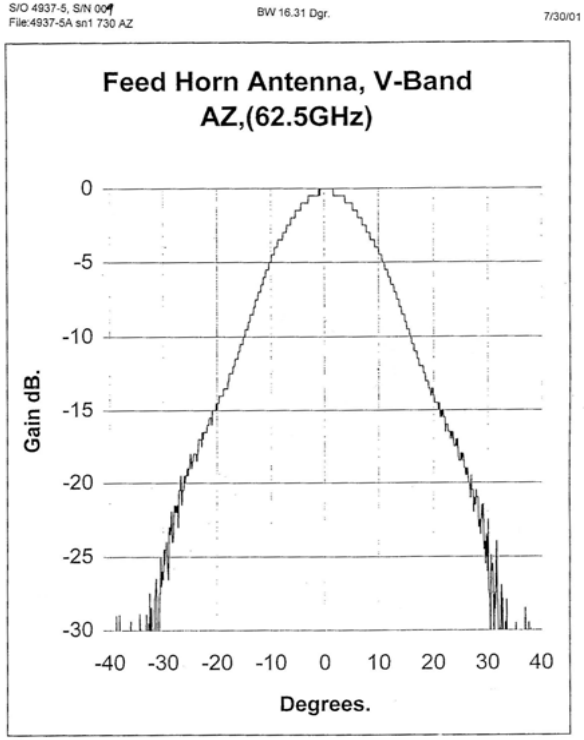
TX Antennas used (Residential, LOS)



62.5GHz/60°horn
Max. of gain: 10 dBi

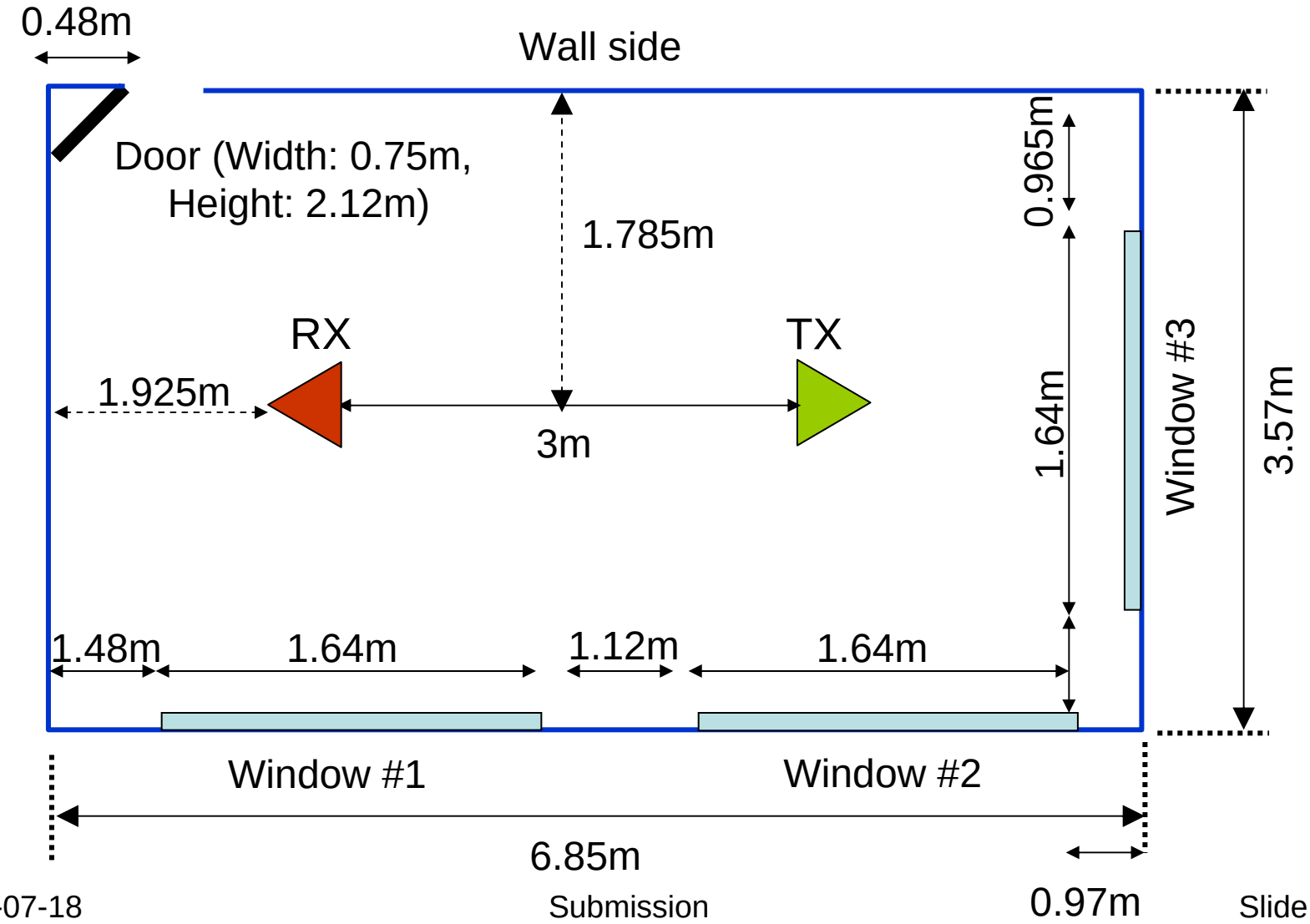


62.5GHz/30°horn
Max. of gain: 16 dBi



62.5GHz/15°horn
Max. of gain: 22 dBi

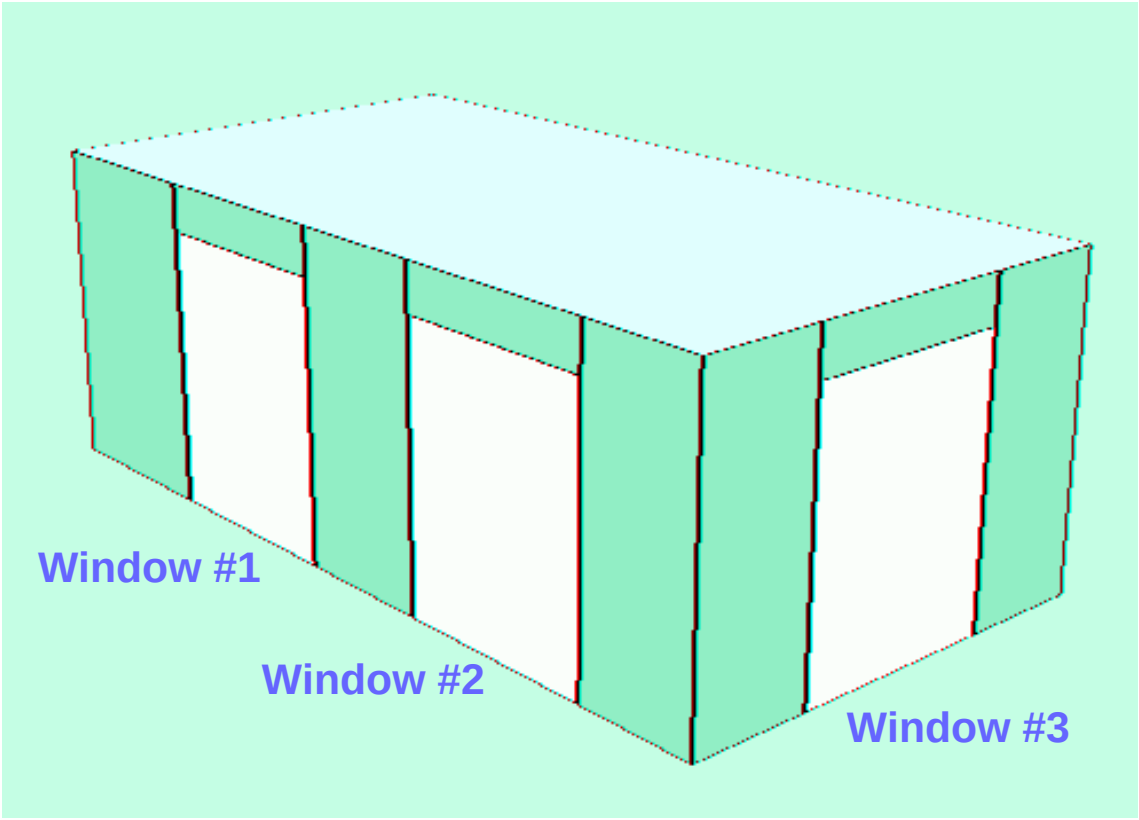
Layout-Geometry (Residential, LOS)



Layout-Geometry (Residential, LOS)

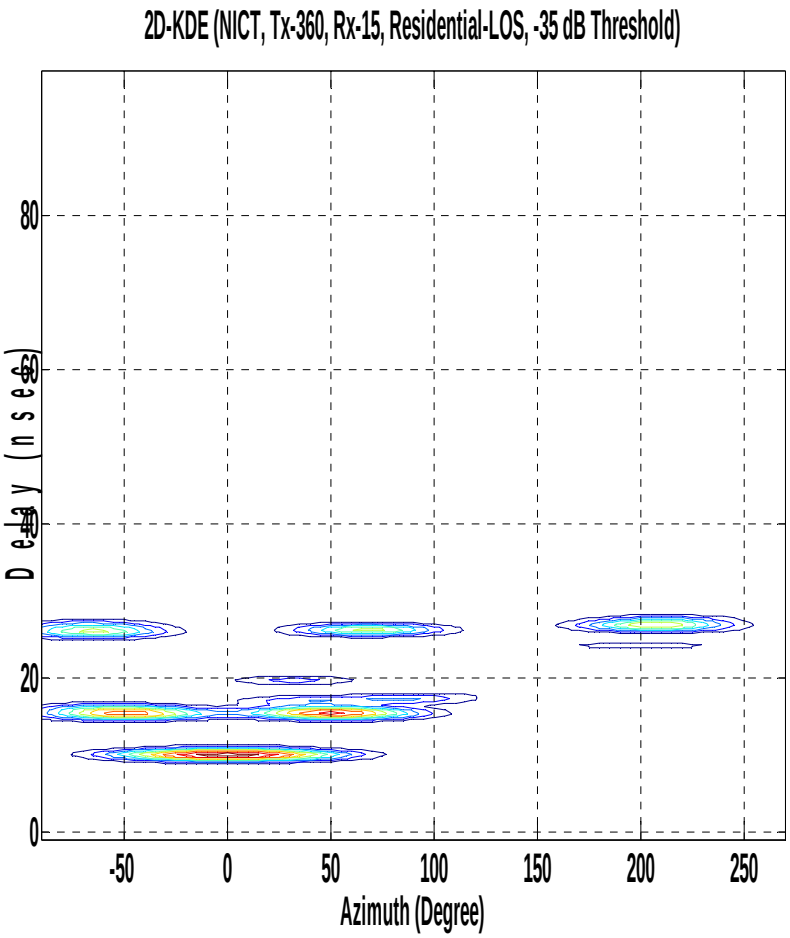
- **Ceiling height: 2.47m**
- **Window Height: 2.11m**
- **TX & RX Height: 1.1m**
- **Polarization : Vertical**
- **Tx antenna: always fixed**
- **Rx antenna: rotated from 0 to 360 degree in 5 degree step**

3D View of the Room

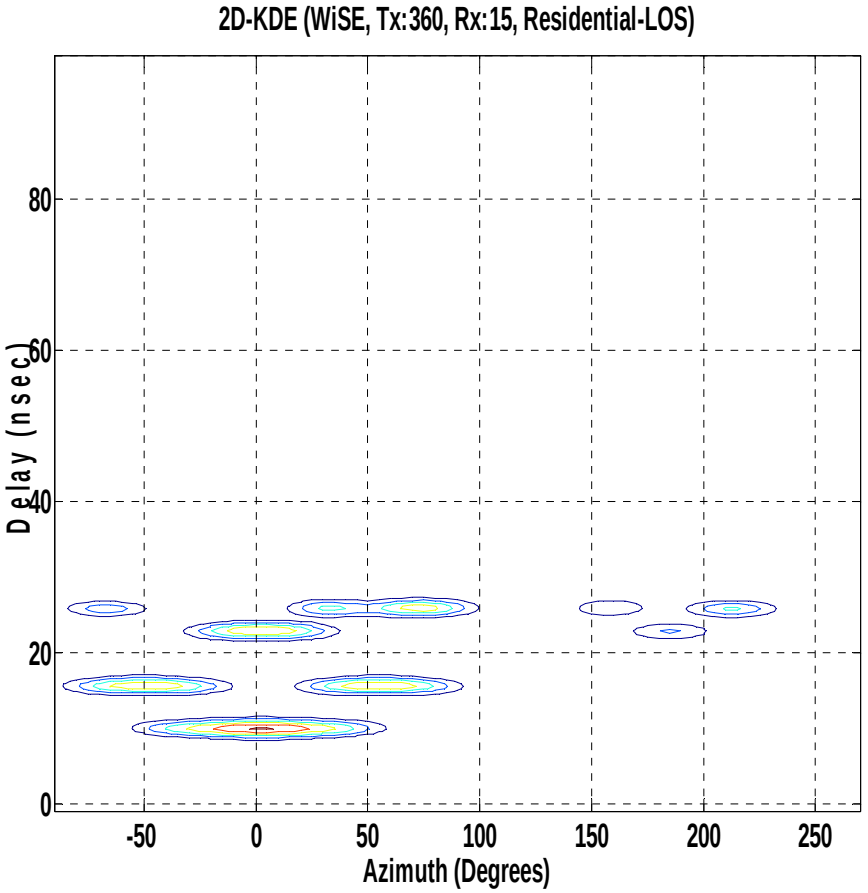


Cluster Identification (LOS, TX:360, RX:15)

Experiment



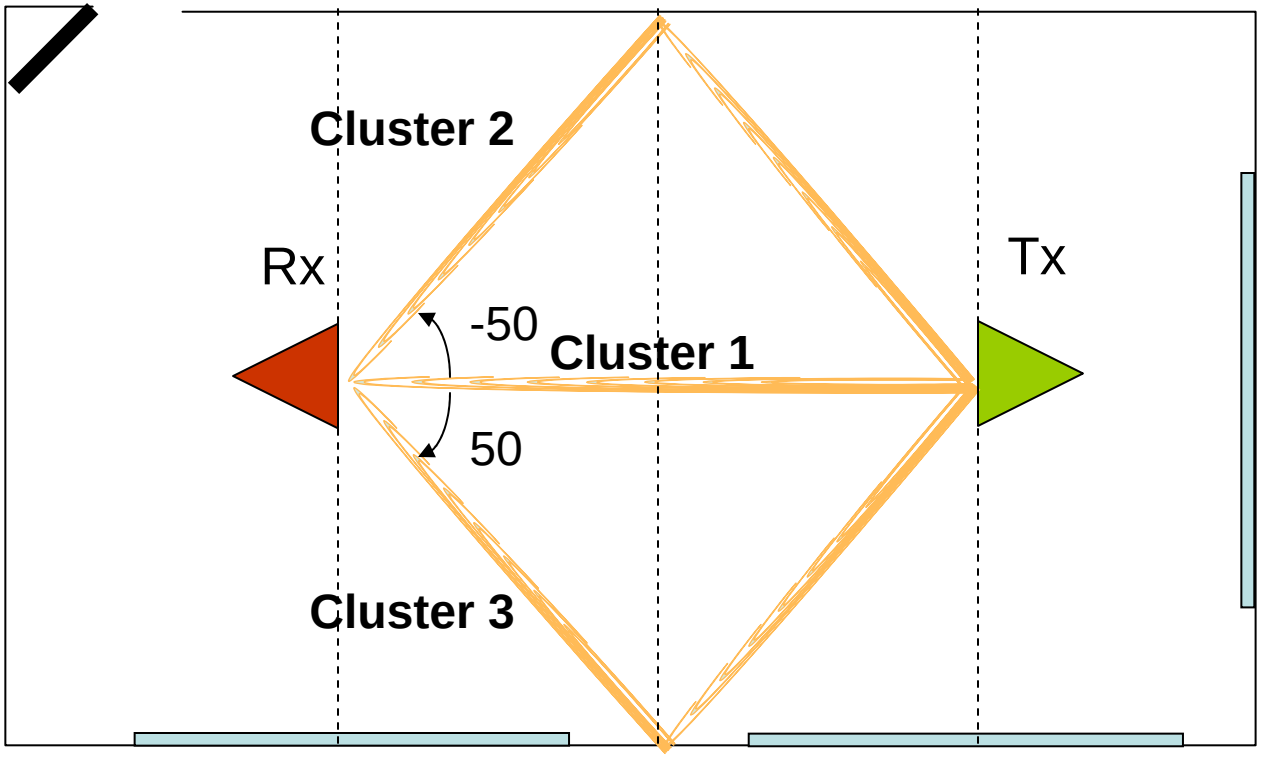
Simulation



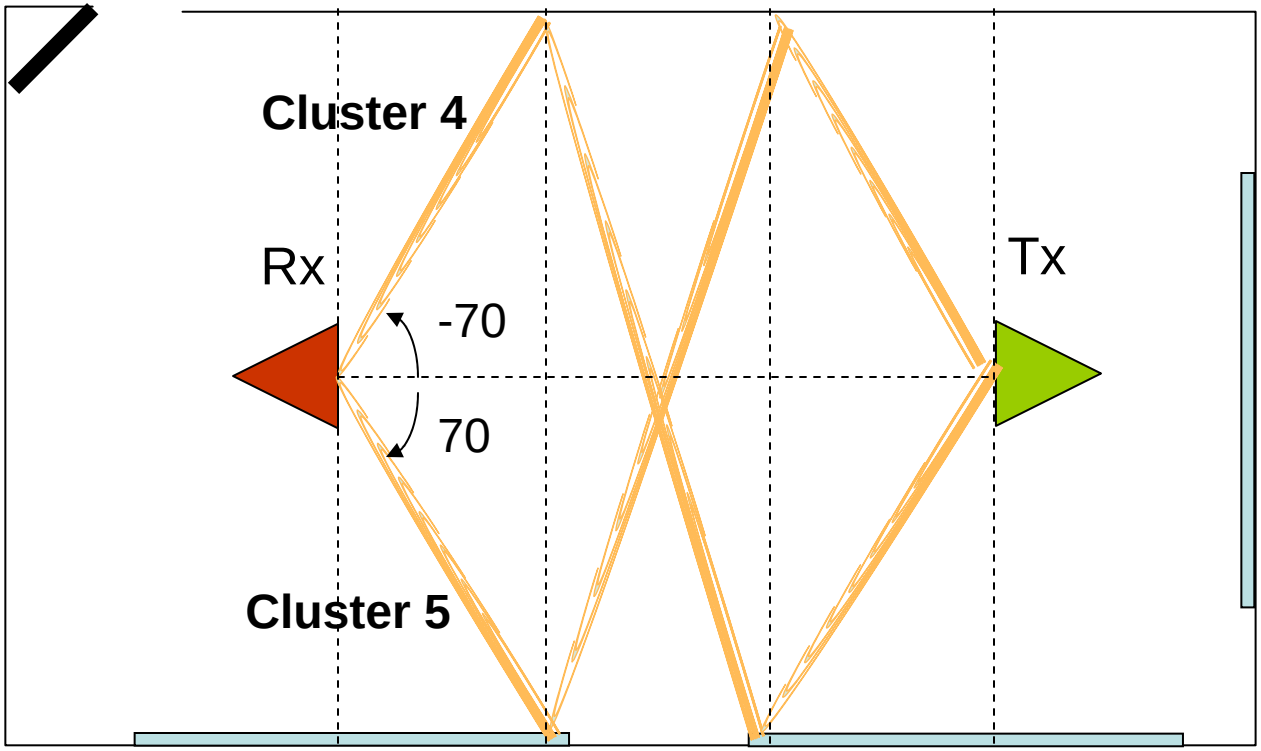
Cluster Identification (LOS, TX:360, RX:15)

Cluster #	Approx. Cluster Arrival Angel (Deg)	Approx. Cluster Arrival Time (nsec)	Experiment	Simulation
1	0	10	✓	✓
2	-50	15.5	✓	✓
3	50	15.5	✓	✓
4	-70	25.75	✓	✓
5	70	25.75	✓	✓
6,7	160, 210	25.75	✓	✓
8	180	22.75	✓	✓
9	0	22.75	?	✓

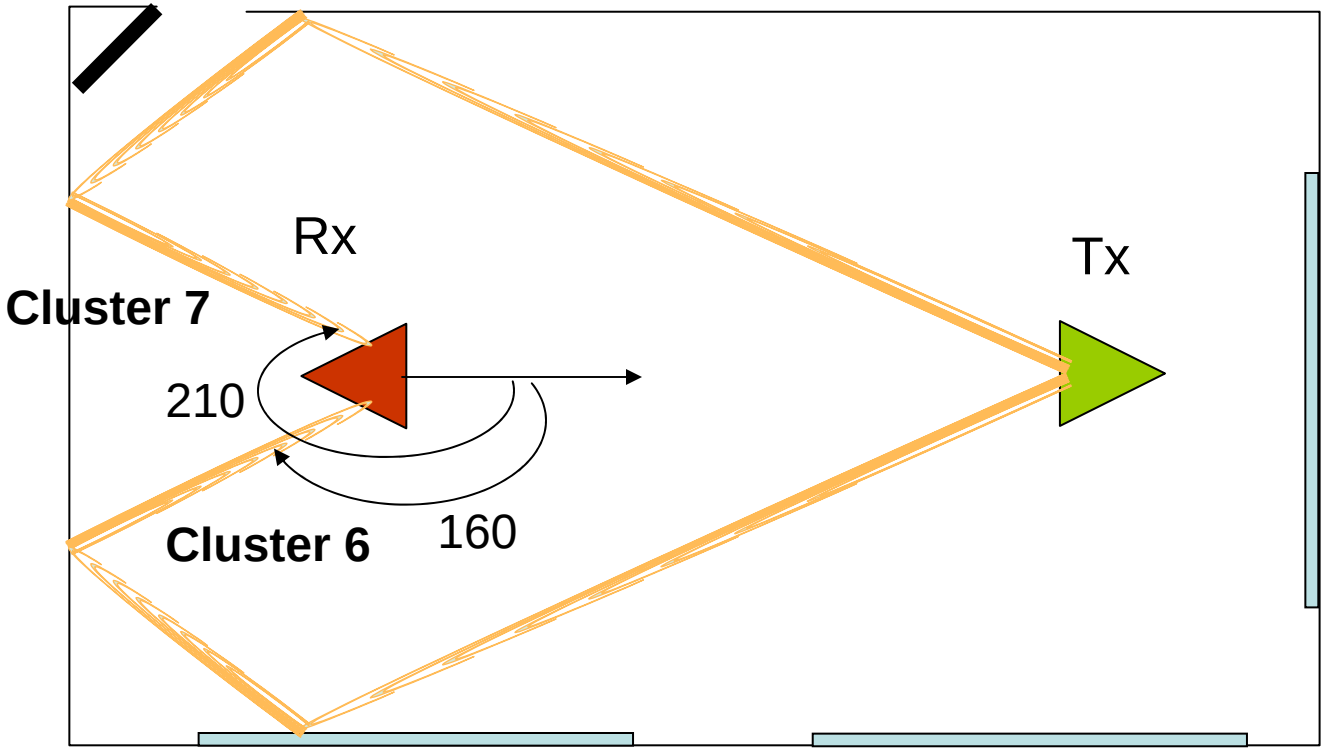
LOS & Single Reflection Clusters (Residential)



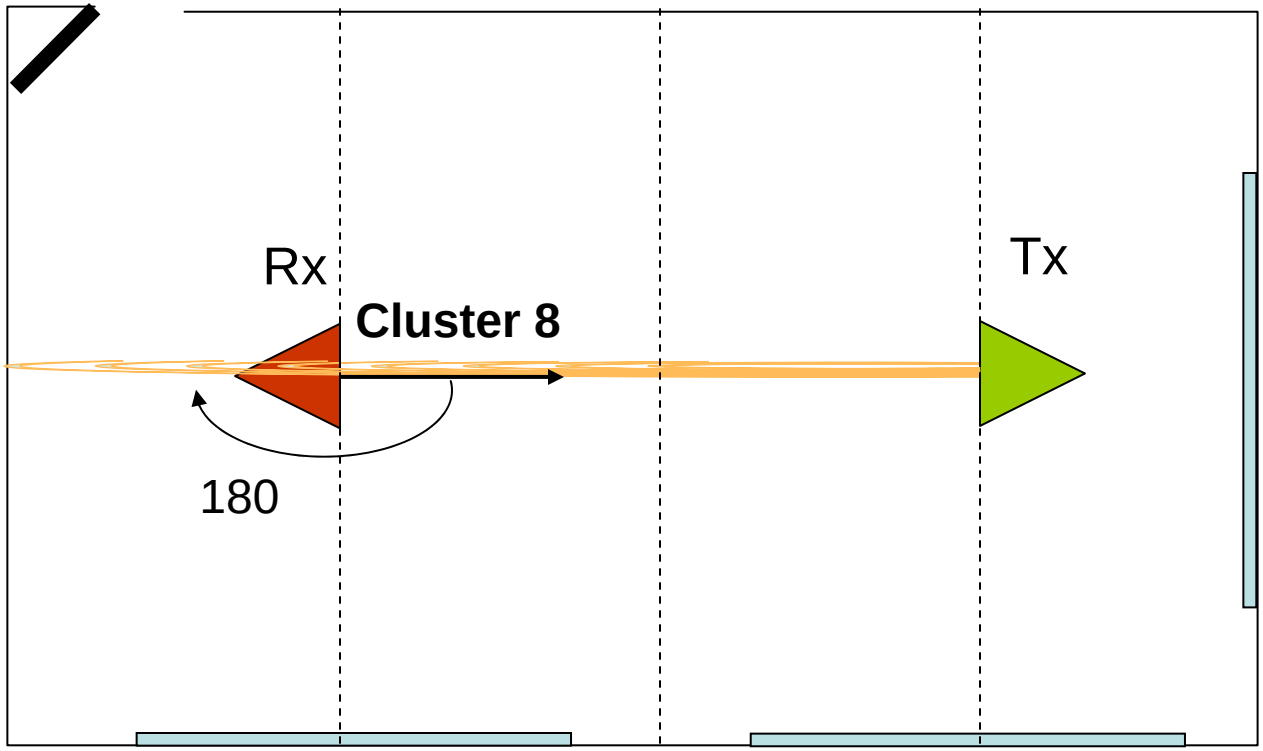
Double Reflection Clusters (Residential)



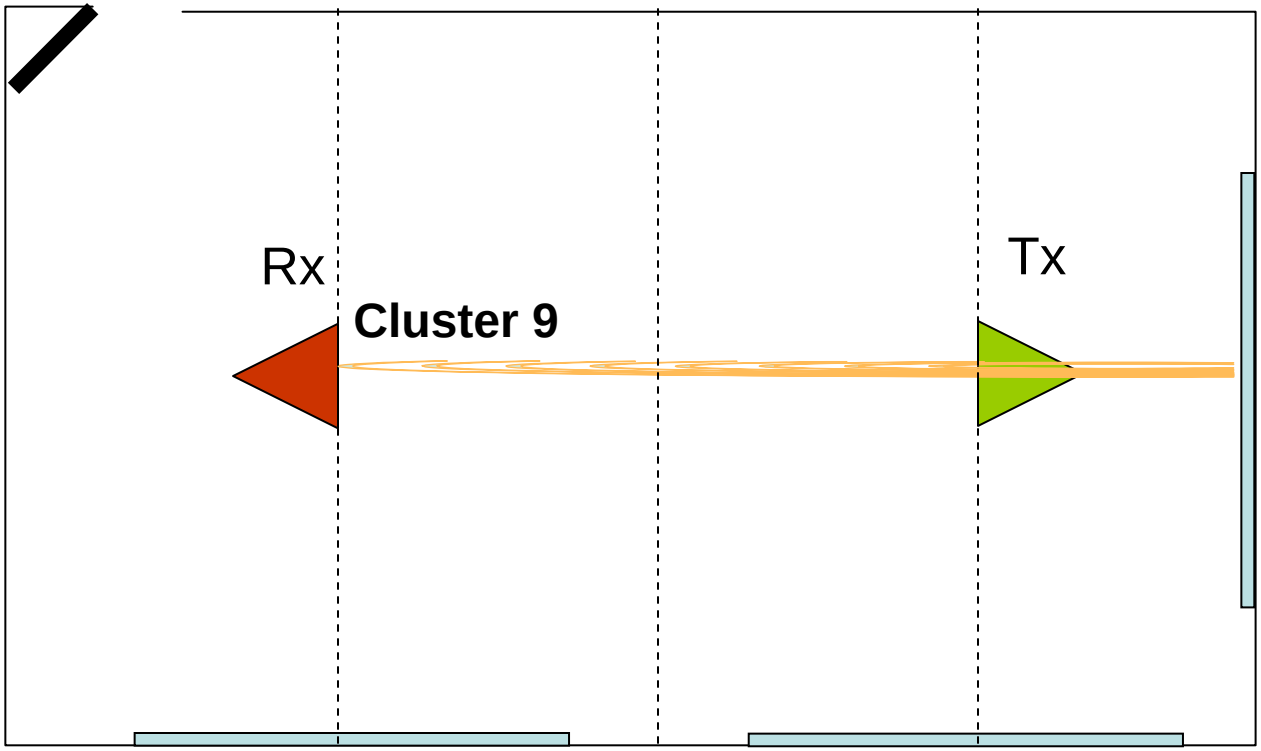
Other Double Reflection Clusters (Residential)



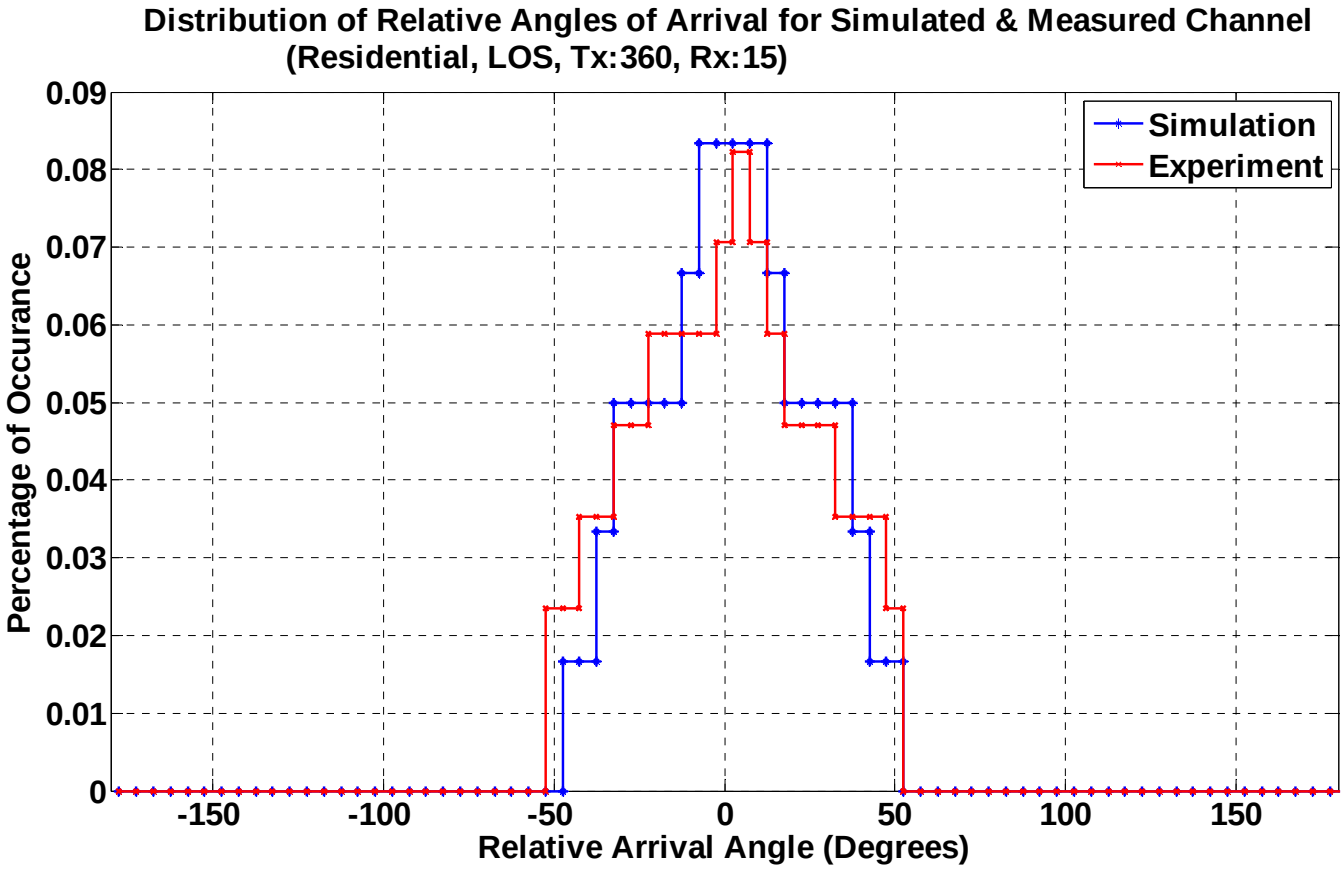
Reflection from the back wall, RX-Side (Residential)



Reflection from the back wall, TX-Side (Residential)



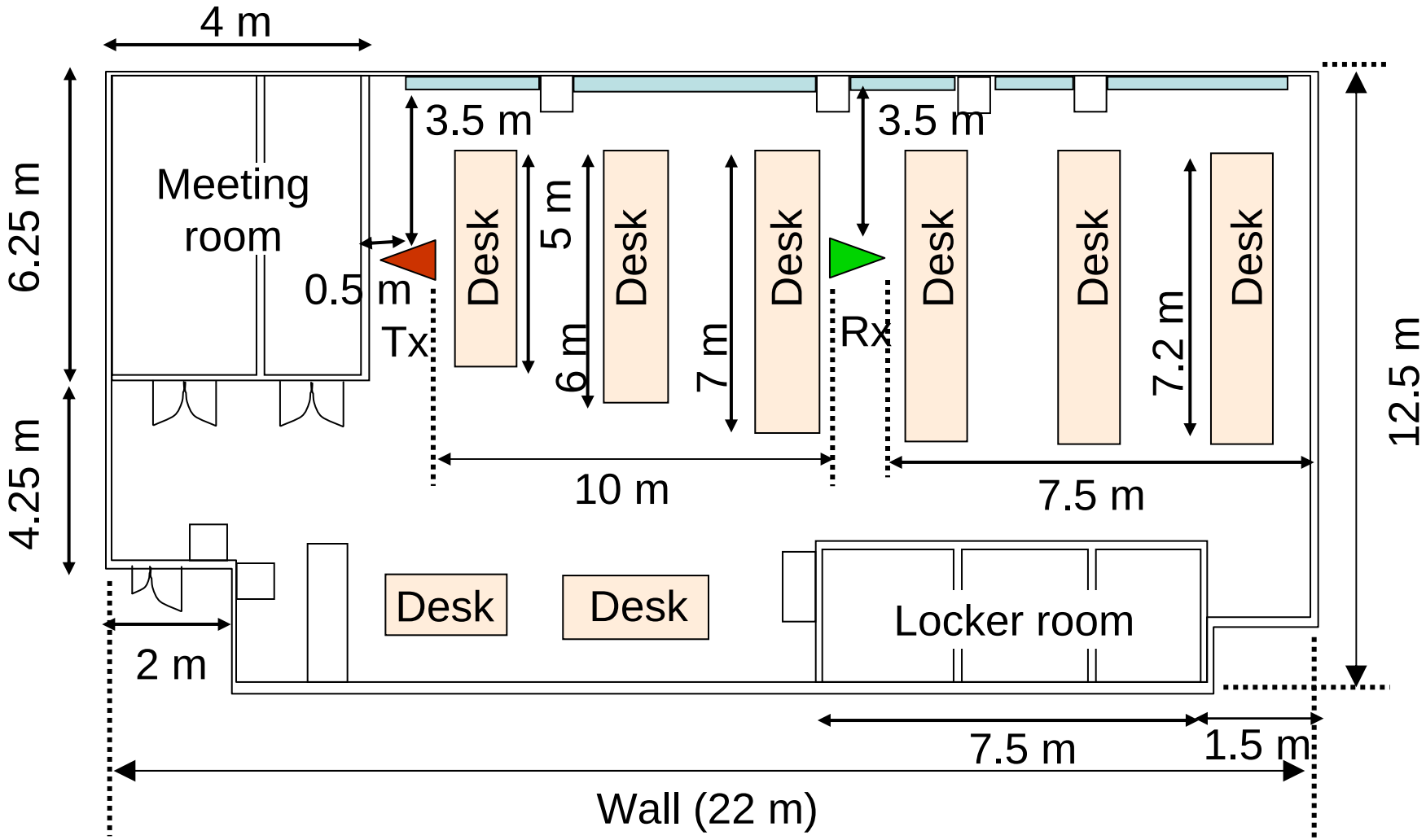
Sample Distribution of the Relative Angles of Arrival (Residential, LOS)



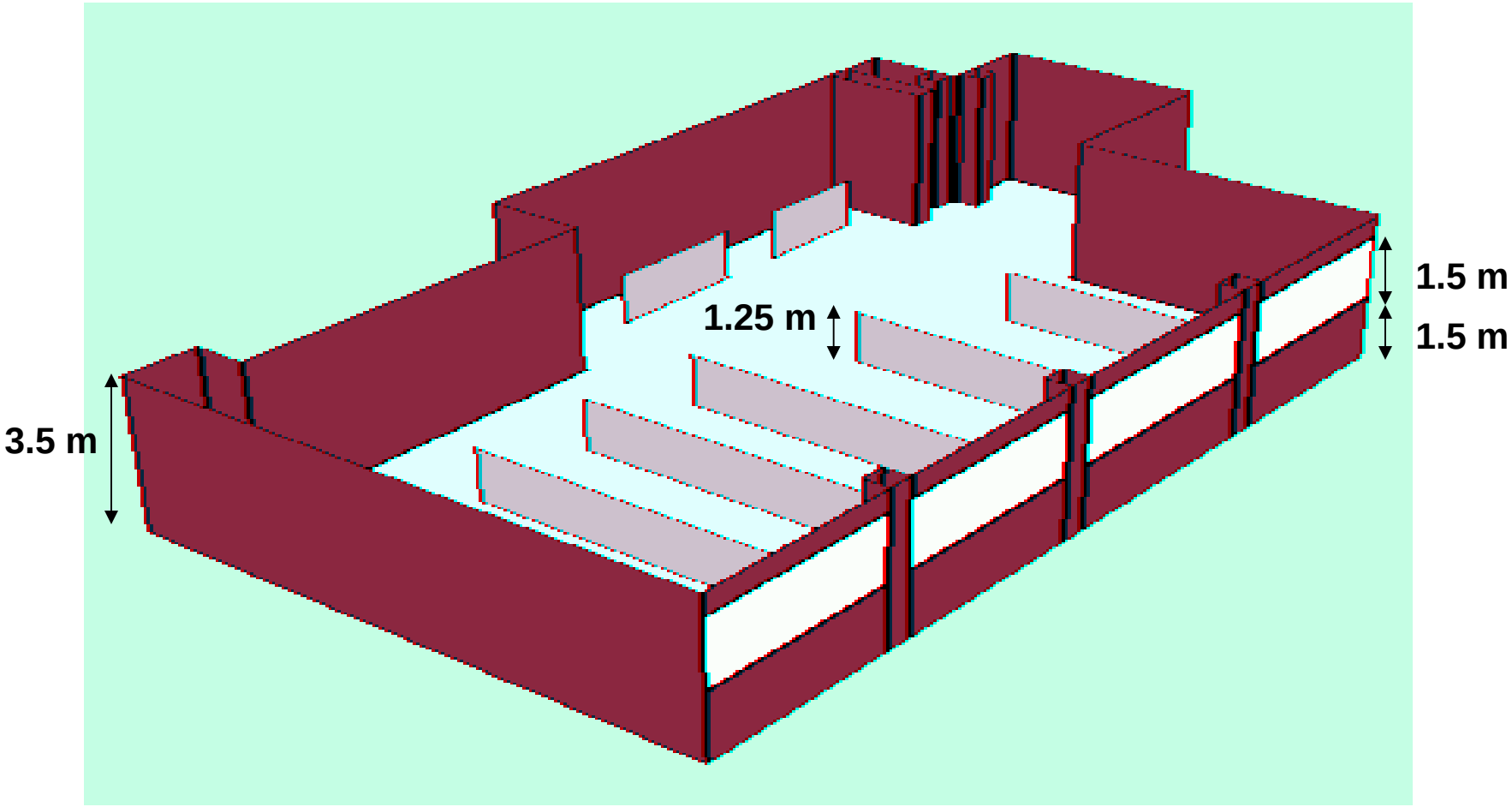
NICT Measurement (Office-NLOS)

- The office room is made of steel wall, steel ceiling and steel floor
- The floor and the ceiling are covered with carpet and plaster board, respectively
- Existing window on one side

Layout-Geometry (Office, NLOS)

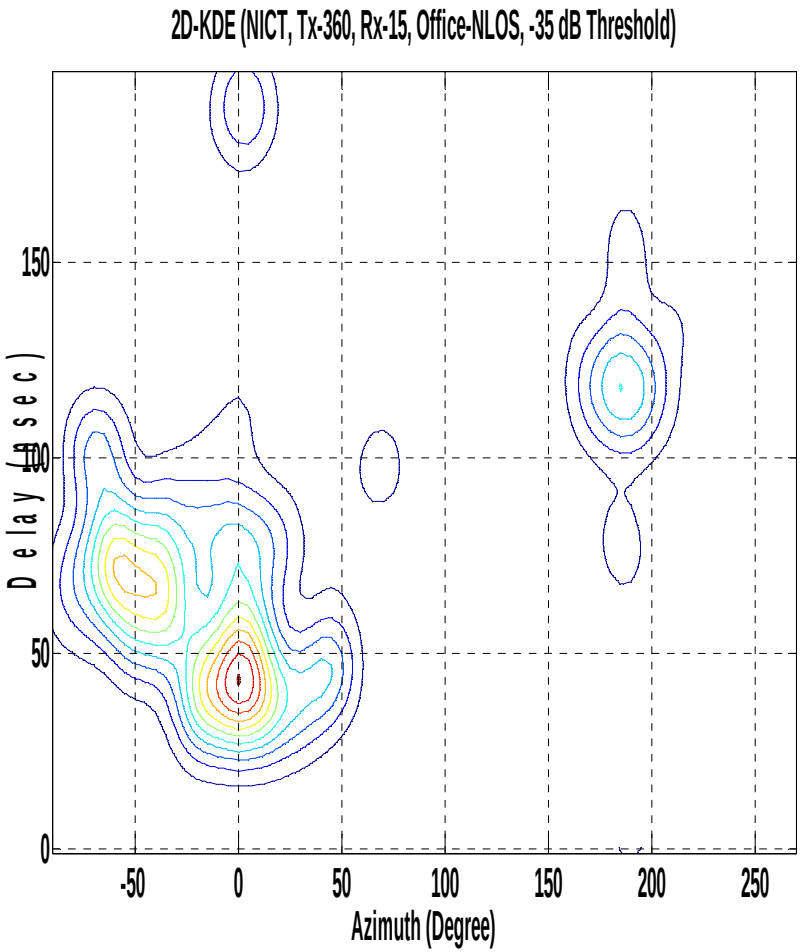


Layout-Geometry (Office, NLOS)

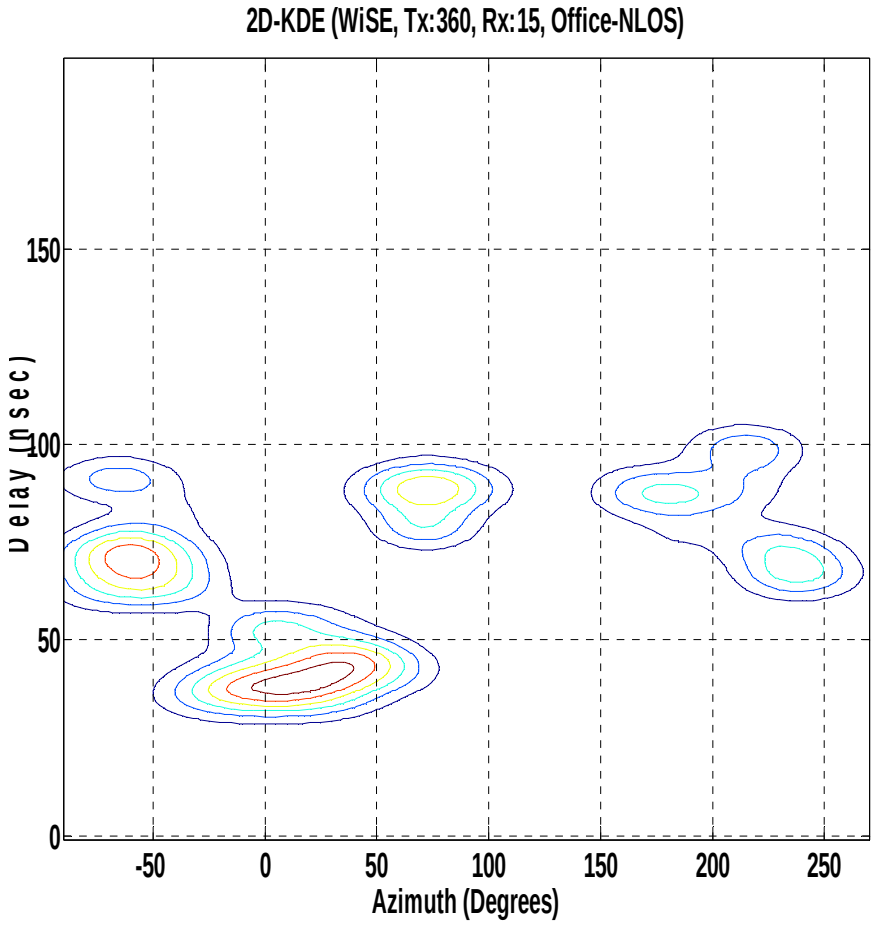


Cluster Identification (Experiment, NLOS, TX:360, RX:15)

Experiment

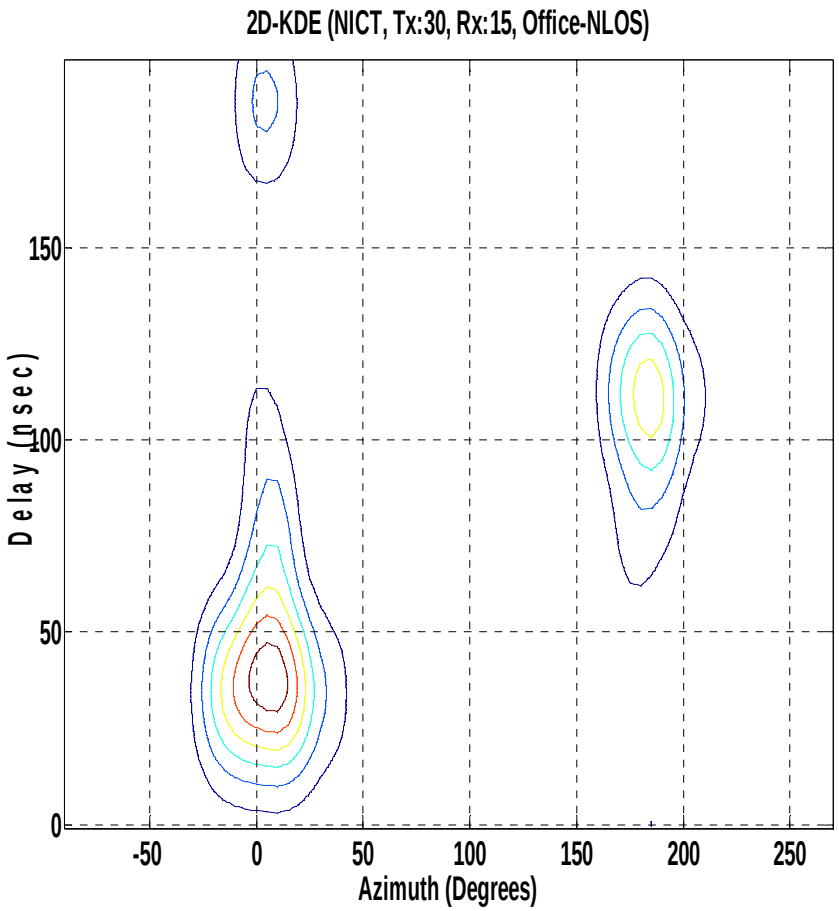


Simulation

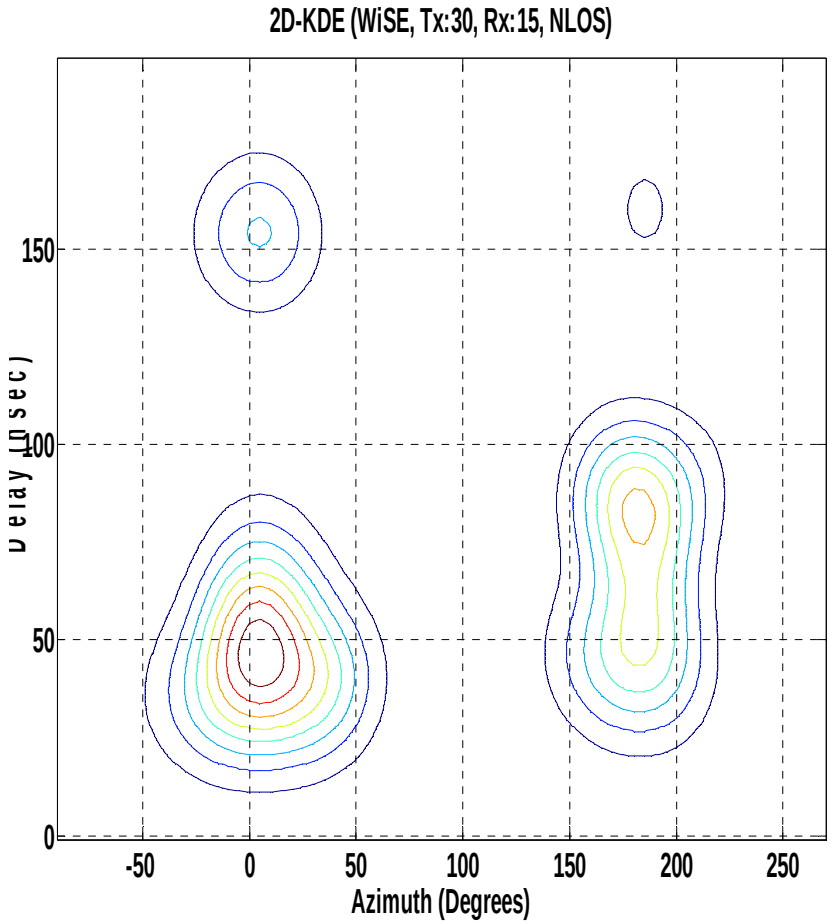


Cluster Identification (Experiment, NLOS, TX:30, RX:15)

Experiment



Simulation



Conclusions

- **For scatter-free environments and LOS scenarios ray-tracing seems to provide a good match for cluster location and intra-cluster statistics**

- **For environments with heavy scattering, NLOS scenarios and directional antennas at the receiver & transmitter, ray-tracing prediction of the clusters still seems to be reasonably close to the result of empirical measurement**

- **More studies are required to further validate the above statements**

References

- "Angle of Arrival Measurement in Home and Office Environments", Hirokazu Sawada, Yozo Shoji, Hiroyo Ogawa, National Institute of Information and Communications Technology (NICT), Japan, doc# IEEE 802.15-06-0012-01-003c

- "Study of the mmW ave propagation modeling to realize WPAN", Toshiyuki Hiroshi, doc# IEEE802.15-03/0365